Today im going to give a short presentation on Consolidation and Retention of Motor Skill after Motor Imagery Training In our daily-life, learning a movement is a complex process that makes an action, like cycling, skiing or playing an instrument, easier and easier to perform as time passes. Complex motor tasks are learned through repetition and training, which result in lasting improvement of the temporal and spatial accuracy of movements

According to Doyon and Benali (2005), the cognitive

processes and the neural substrates that mediate our capacity to learn follow distinct phases: a “fast (early) learning stage”, that occurs within the first training sessions; a “slow (later) stage and consolidation” during which further improvement takes place after several sessions of practice, depending on task complexity, and even after some hours from the last session, with no further practice (off-line learning). When consolidation has occurred, cognitive resources are less needed (“automatic stage”). The final stage of motor learning is the “retention stage”, when the movement is effortless and can be easily executed after a long period from the last training session.

The learning of a motor skill is normally attained via physical repetition of the skill (Coker, 2009). However, research has shown that cognitive training, such as motor imagery (MI) and action observation training, can also be applied to effectively facilitate skill learning, either alone, or combined with physical practice (Hodges and Williams, 2012).

MI is a dynamic state during which motor actions are mentally simulated, without actual movement (Decety, 1996; Jeannerod, 1995). Motor imagery training has been used as an effective resource to facilitate motor learning (Avanzino et al., 2015; Kim et al., 2017; Schack et al., 2014). Indeed, meta-analyses on this topic have reported that motor imagery training has a positive effect on motor performance, even though the degree of its effectiveness varies with some factors, such as type of task, experience level of participants or duration of practice . Furthermore, motor imagery training has been shown to be more effective compared to no practice in inducing motor performance improvements, even in the process of learning a novel kinematic pattern (Ingram et al., 2019),

Here we were interested to design an experimental task able to test for the fast and slow learning phases and for retention of motor skills for both MI and ME. The aim of this study was to assess whether a training based on the cognitive representation of movement and characterized by lack of somatosensory feedback, i.e. MI, differently affected the phases of motor learning, with respect to movement execution (ME). We hypothesize that differences between MI and ME training would emerge in terms of reduced consolidation and retention of motor skills.

Participants trained and their performance was assessed over a

period of 15 days, following an experimental design already described in the literature to assess early, later stages of learning and retention

Each training session lasted about 10–15 min. In the first two days, subjects executed the first two training sessions, once per day (TRAINING 1 and TRAINING 2 sessions). Motor performance was evaluated before training (Baseline), 5 min immedi-ately after the end of each training session (TR1þ5M, TR2þ5M) and 2 h after the second training session (TR2þ2H). We defined this block as “the first learning phase”. On day 3 participants did not train, but motor performance was assessed (TR2þ1D). On day 4 and on day 5, training subjects executed two further training sessions, once per day (TRAINING 3 and TRAINING 4 sessions). Motor performance was evaluated before training (TR2þ2D), 5 min immediately after the end of each training session (TR3þ5M, TR4þ5M) and 2 h after the second training session (TR4þ2H). We defined this block as “the second learning phase” and it was instrumental for assessing consolidation of motor learning. Finally, to evaluate the long-term retention of motor skill learning participants performed further assessment tests on day 8 and on day 15 (TR4þ3D, TR4þ10D).

All the participants had a short familiarization session during which

they had to perform 3–5 trials, until they were able to perform the task

without errors, at a spontaneous velocity (Bove et al., 2007; McAuley

et al., 2006) with the right hand. After this short session, all participants

reported being comfortable with the task. Then, ME training consisted in

performing as fast as possible 10 blocks of 4 sequence repetitions with

10 s rest between the blocks with the right hand (

. The MI practice consisted in imagining the same task, with a different fingers sequence, but of similar complexity. Precisely, participants were asked to imagine themselves performing the movement (“kinaesthetic imagery”), as they would actually do (Gentili et al., 2010). They were asked to feel the motion of their fingers and the contact between the distal phalanx of the thumb and those of the other fingers.

**results**

Behavioural parameters (Inter tapping interval, ITI, Touch Duration, TD, and movement Rate) recorded during the 1st and the 2nd learning phases. indicates significant GROUP x TIME � PHASE interaction with post hoc showing that TD was not further reduced by the training sessions during the 2nd learning phase in the MI group whereas it was in the ME group. � indicates significant PHASE � GROUP interaction, with post hoc showing that movement rate was higher when training was based on ME respect to MI during the 2nd learning phase.

Behavioural parameters (Inter tapping interval, ITI, Touch Duration, TD, and movement Rate) recorded during consolidation and retention phases, with post-hoc analysis showing significant differences between ME and MI group at each testing time (p always <0.05).

5. Conclusion

Here we analyzed, for the first-time motor performance changes during a multiple-days learning task based on mental imagination of a novel motor sequence. Our results confirmed the idea that a training based on motor imagery is able to induce learning, even if consolidation and retention of motor skills are less effective than movement execution. These behavioral findings are in line with recent neurophysiological findings indicating differences in neuroplasticity mechanisms between MI and ME, and are possibly due to differences in bottom-up (somatosensory) mechanisms involved. To better understand the neurophysiological mechanisms at the basis of our findings, it would be of interest to record cortical excitability changes over the different phases of motor learning trough MI. Finally, to confirm the role of the sensory feedback on motor skill retention, it would be useful to test the effect of a training based on the combination of sensory feedback and motor imagery on the long-term.

This study highlighted the issue of long-term performance gain after motor imagery training. In fact, we observed a reduction of motor im-provements in the group that trained with MI days after the last training session. The tendency of improvements to fade soon after the end of exercises could be a limitation to all those techniques that do not involve

movement